MECHANICAL VARIABLES OF JUMPING DURING NAVAL ACADEMY OBSTACLE COURSE TRAINING ACTIVITIES

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## INTRODUCTION

As regulated by the U. S. Department of Defense, all military personnel must undergo some type of physical readiness program (Myers, Gebhardt, Crump, & Fleishman, 1984). As part of this program, individuals must complete tasks that could have job relevance. One of the tasks is clearance of a vertical structure on an obstacle course. This vertical obstacle poses many problems, particularly with women, who may lack the upper body strength to pull themselves toward the top. Research has shown, however, that physical fitness scores for women cadets have consistently shown 50-80% improvement rates from entry into the Academy until graduation (Baldi, 1991). Because of these improvements throughout the years, physical performance standards have been upgraded. The U.S. Navy has incorporated gender neutral standards into training regimes, and the obstacle course has been one source used to assess these measures. The purpose of this study was to determine which variables contributed to a successful jump and if the jump assisted in the upper body pull to clear the vertical structure. Additionally, to determine if differences existed between males and females on strength, anthropometric, and performance variables. If differences do exist, how might gender neutral standards affect the performance standards for both males and females.

## METHODS

Five males (age: 20.2 yrs $\pm$ 1.3; hgt: 178.6 cm $\pm$ 3.7; wgt: 77.4 kg $\pm$ 7.7) and five females (age: 20.0 yrs $\pm$ 1.9; hgt: 170.64 cm $\pm$ 7.3; wgt: 63.8 kg $\pm$ 8.5),all midshipmen at the U.S. Naval Academy, volunteered as subjects. Subjects taller than 173 cm jumped a 2.4 m shelf, while those under 173 cm jumped a 1.8 m shelf. The shelf was a horizontal platform without a vertical support for the subjects to use to propel themselves upward. Subjects were filmed for 1 trial from the sagittal and posterior views at 60 Hz. After data collection, the video images were captured, digitized, transformed to three-dimensional images, and smoothed (digital filter set at 10 Hz) using the Ariel Performance Analysis System (APAS, LaJolla, CA). The kinematic variables investigated included linear displacement of center of gravity x, y, z (COG); total movement time (TT); vertical velocity at takeoff (VEL-TO); and absolute angles at the hip (HP), knee (KN) and ankle (AK). Subjects were measured for percent body fat (%BF), leg length (LL), knee flexion peak torque percent body weight strength (KFT%BW) and knee extension peak torque percent body weight strength (KET%BW). Standard protocols were used to collect the descriptive and strength data with Lange skinfold calipers, Cybex 6000 and anthropometer.

**RESULTS**

All 10 subjects were able to successfully clear the shelf. However, the females took greater total movement time (2.26 sec) to finish the task. Descriptive data of the strength and anthropometric data (see Table 1) kinematic data (see Tables 2 and 3) indicated mean differences between males and females. Statistical differences using two sample t tests ($p \leq 0.05$) were found for several, anthropometric, strength and kinematic variables.

Table 1. Descriptive data for strength and anthropometric data.

| | %BF | LL (cm) | KFPT%BW | KEPT%BW |
|---|---|---|---|---|
| MALE | 7.32 $\pm$ 1.5 | 111.4 $\pm$ 5.6 | 88.2 $\pm$ 10.4 | 127.6 $\pm$ 15.3 |
| FEMALE | 18.72 $\pm$ 3.6 | 104.3 $\pm$ 7.4 | 46.6 $\pm$ 5.8 | 73.4 $\pm$ 8.5 |

*M $\pm$ SD

As shown in Table 1, the subjects were close in age but the males were taller, heavier and stronger. The males generated 90% greater velocity and displaced their COG 14 cm higher at takeoff (see Table 2). The males all jumped the taller structure, whereas three of the females jumped the shorter structure. Maximum vertical velocity must be achieved at takeoff for maximum height. The males displaced their COG approximately 15 cm higher than the females. However, when compared to actual height the males displaced their COG approximately 48% and the females' 41%. When looking at the height of the shelf, the shorter females actually displaced their COG vertically upward greater than the males and taller females.

Table 2. Linear displacements and velocity

| | LIN. DISP. X (cm) | LIN. DISP.Y (cm) | LIN. DISP. Z (cm) | VEL-TO Y (m/s) |
|---|---|---|---|---|
| MALE | 9.82 $\pm$ 3.6 | 84.85 $\pm$ 23.9 | 51.03 $\pm$ 18.9 | 5.65 $\pm$ 1.3 |
| FEMALE | 9.63 $\pm$ 2.9 | 69.37 $\pm$ 31.2 | 65.28 $\pm$ 21.5 | 5.11 $\pm$ 1.8 |

*M $\pm$ SD

Increased hip flexion (HP FLX) and extension (HP EXT) was seen with the female subjects (see Table 3). The females crouched to a greater depth at the hip, whereas the males used increased knee flexion (KN FLX) and extension (KN EXT) and ankle dorsiflexion (AK DF) and plantar flexion (AK PF). Two strategies were identified between the male and female subjects. Males were able to convert their horizontal velocity into maximum vertical velocity more effectively than females. The females would stop their horizontal momentum to crouch very low and then pull themselves up onto the shelf, thus creating additional force requirements for upper body strength. The males continued their forward momentum with a decreased crouch and more explosive power from the lower legs.

Table 3. Angular displacements of the hip, knee, and ankle (°)

| | HP FLX | HP EXT | KN FLX | KN EXT | AK DF | AK PF |
|---|---|---|---|---|---|---|
| MALE | 48.9 | 47.8 | 66.1 | 68.5 | 64.6 | 57.3 |
| SD | 12.4 | 13.5 | 7.9 | 8.9 | 6.7 | 5.6 |
| FEMALE | 68.3 | 77.2 | 59.8 | 72.1 | 50.9 | 45.4 |
| SD | 18.9 | 18.5 | 7.1 | 7.0 | 5.6 | 5.0 |

* M $\pm$ SD

Statistical differences using two sample t tests ($p \leq 0.05$) were found between males and females with the following variables: hgt, wgt, %BF, LL, KFPT%BW, KEPT%BW, KN FLX, and HP EXT. The males were able to utilize their decreased body fat and increased strength to maximize lower body linear and angular variables.

## CONCLUSIONS

Significant differences existed for the lower body between males and females when completing a jump to clear a vertical structure. Upper body components were not investigated in this study, however, the lack of horizontal to vertical velocity transfer for the females would seem to indicate an increased need in upper body strength. Because the U.S. Navy has proposed the incorporation of gender neutral standards into their physical training readiness programs, the use of the obstacle course may not be the most appropriate activity for measuring these standards. Gender norming or adjusting of scores based on age or sex for completion of a task, not job related, may decrease the potential pool of candidates.

## REFERENCES

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